MONITORING AND CONTROL OF ALUMINUM SALT CONCENTRATIONS IN THE PROCESS OF DRINKING WATER TREATMENT

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Abstract

One of the most recurring causes of the presence of aluminum in drinking water is the addition of aluminum salts as a coagulating agent. The use of this adjuvant requires the installation of the particular pH conditions, which if not implemented lead to higher concentrations in the treated waters. The presence of this salt may also indicate poor coagulation conditions, which could impair the final quality of the treated water.

The objective of this work is to evaluate the aluminum concentrations in the various surface water treatment works of the Taksebt dam treatment plant (from the inlet of the station to the outlet of the reservoir) by the LCK 301 method.

This study showed that the analytical results at the SEEAL laboratory level in the treated waters are pH-related and that these concentrations are below the standard set at (0.2mg/l)

Key words: *Coagulant, Flocculent, Aluminum sulfates, pH, Surface water*

INTRODUCTION

Surface water is constantly approaching its qualitative and quantitative limit. To this end, it is necessary to put in place treatments that are increasingly robust and ingenious in order to correct as much as possible their quality, which would threaten the noble vocation of this resource. (METAHRI, 2015).

In the treatment of clarification of surface water using adjuvants such as aluminum or iron salts, the presence of these products in water can cause a major ecotoxicological problem. The presence of aluminum is detrimental to the environment and public health (CHERIFI, 2013).

Origin of Aluminium

Aluminium is the metal element most abundant and the third component of the Earth's crust. In a natural state, Aluminium is never found in the form of metal; very reactive, it is always combined with other elements like the oxides (alumina), the hydroxides coming primarily from bauxite, the silicates coming from clay and the micas, and of the water-soluble forms complexed with sulphates, nitrates, chlorides in the presence of matter organic dissolved.

Moreover, Aluminium in solution strongly influences chemical and biological quality solutions of ground and surface water (ROSIN, 1990).

Distribution and transfer of Aluminum in water

Aluminum is present naturally in spring waters, it is found in three forms: insoluble, colloidal and soluble; Corresponding to silico-aluminates, hydroxides, free or complex forms, mineral or organic (CHERIFI, 2013).

Water treatment plants are the main consumers of aluminum sulfate, aluminum chloride and other aluminum-based polymer products.

The aluminum salts serve to ensure the coagulation and flocculation of the suspended or soluble fine particles, to allow sedimentation and filtration; during the agglomeration or coagulation process, most of the aluminum associated with the added aluminum salts hydrolyses to produce aluminum hydroxide, which precipitates and becomes an integral part of the flocculate (HEALTH CANADA, 2010).

The ability of aluminum compounds to dissolve in water depends on the condition of the water, mainly its PH (MEGHZILI, 2012).

Coagulation process

Aluminum sulfates are products capable of neutralizing the charges of colloids present in water. (CARDOT, 1999). The reactions can be represented as follows:

$$Al_2(SO_4)_3 \xrightarrow{\text{Step 1}} Al_x(OH)_y(SO_4)(SO_4)_z \xrightarrow{\text{Step 2}} Al(OH)_3$$

Step 1: is a hydrolysis phase; positively charged intermediates are formed and are very effective in neutralizing the negative primary charge of the colloids. These compounds have an aluminum atom whose oxidation number is very large. This is the true coagulant form that destabilizes negatively charged particles. This step depends on the temperature and requires a PH compatible with the existence of these poly-charged intermediates.

Step 2: allows the formation of the $Al(OH)_3$ precipitate which ensures the bridging and the coalescence between the destabilized colloids (formation of the flocculant), it depends on the agitation of the medium.

Presentation of the study area

Metamorphic rocks (schists, micachists and gneisses) essentially constitute the geology of the Oued Aissi watershed. In the upstream part, there are sedimentary formations formed by the limestone chain of the Djurdjura. Along the talwegs are alluvial terraces formed by gravel and sand. In addition, outside alluvial terraces and limestone formations, most of the basin is not very permeable. This therefore promotes surface flow.

Location of the Taksebt Dam

The TAKSEBT dam is located on the oued Aissi, a tributary of the Sebaou, about 7 km southeast of the city of Tizi-Ouzou and 100 km east of the city of Algier, Figure 1.

Figure 1. Location of the Taksebt Dam (Google Earth).

The reservoir created by the dam has a capacity of 175 million m^3 allowing a regularization of 180 million m^3, intended for the supply of drinking water and divided as follows:

- 173 000 m^3/day for the city of Tizi-Ouzou;
- 60,000 m^3/day for the city of Boumerdes;
- 235 000 m^3/day for the city of Algiers.

Presentation of the potabilisation station

The water treatment plant is about 8 km from the Taksebt dam. It was commissioned in May 2007. It occupies an area of 34 hectares and has been sized to treat a maximum water flow of 616 000 m^3/day, figure 2.

Figure 2. Location of the Taksebt drinking water treatment plant

The water supplying the treatment station comes in a gravity way from the TAKSEBT dam, which is in turn fed by the Oued AISSI and the Oued Bougdoura. The station is designed to supply drinking water to the following municipalities: Freha, Azazga, Draa ben Khedda, center Wilaya of Tizi-Ouzou and Algiers.

Transportation is carried out by gravity from the treatment station to the DRAA BEN KHEDDA treated water tank, and then water continues to be transferred through the melt lines and tunnels to the BOUDOUAOU reservoir. Throughout the transfer, pipes are operated to supply the towns of TiziOuzou and DRAA BEN KHEDDA.

Capacity of the station

The station's nominal hydraulic capacity is 647 000 m^3/day, taking into account a 5% recycled flow rate of the raw water flow. The nominal production of the TAKSEBT treatment plant is 605 000 m^3/d based on a gross supply of 616 000 m^3, See table 1.

Table 1. Characteristics of the Taksebt treatment station.

Characteristics	**Capacity**
Raw water flow	616 000 m^3/d
Volume of sludge extracted from clarifiers	7 400 m^3/d
Volume of sludge extracted from filters	3 600 m^3/d
Production of treated water	605 000 m^3/d

Processing chain

The raw water from the Taksebt Dam is treated before it is conveyed to the incoming pumping station figure 3.

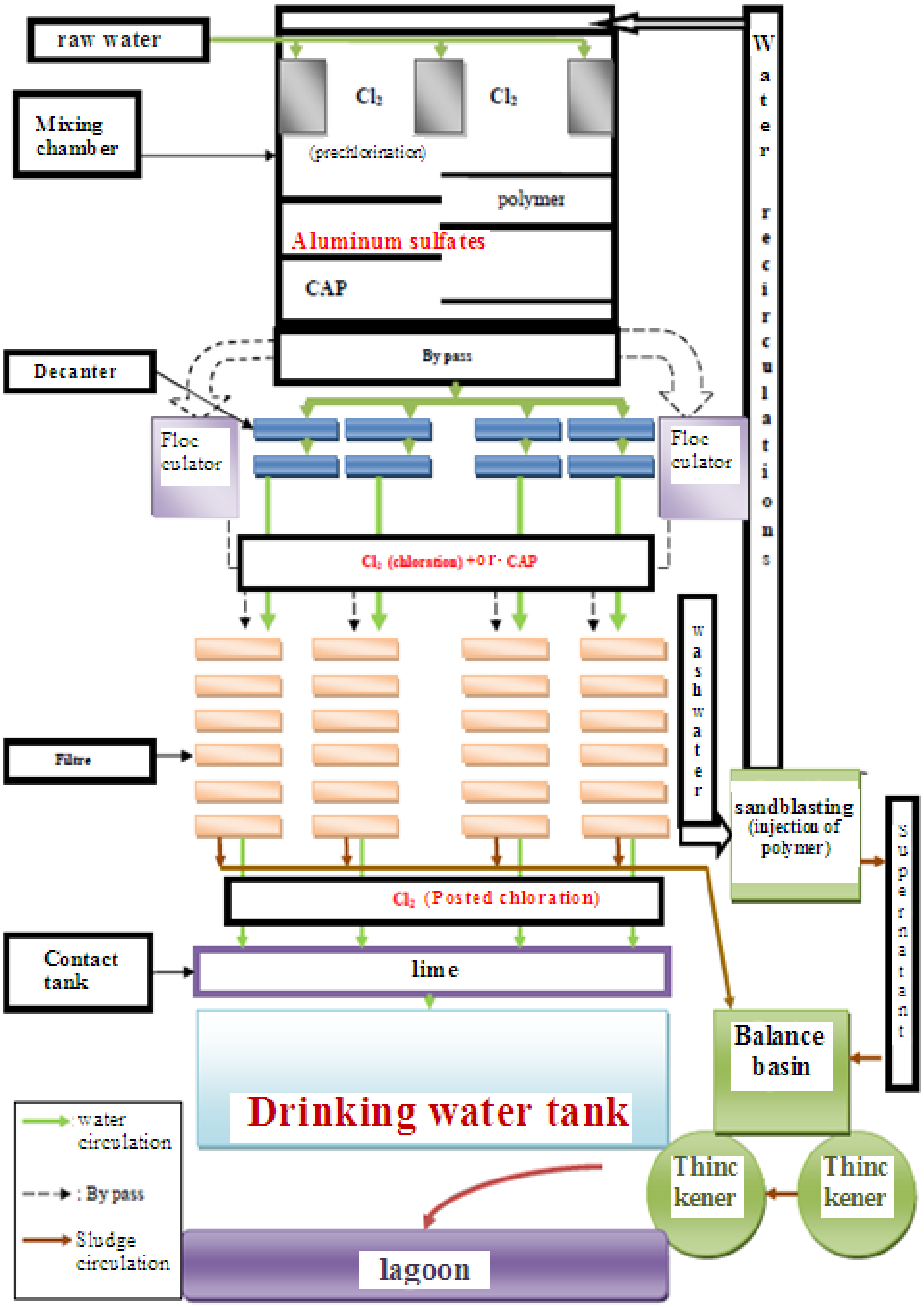

Figure 3. General diagram of the operation of the Taksebt water treatment plant.

Sampling

Direct sampling from several taps, which are located in the analysis laboratory, monitors aluminum content, open 24 hours a day, so as not to modify the organoleptic, physico-chemical and bacteriological parameters of the water. The results of the analysis of all the samples vary according to the water treatment works:

- Raw water at the entrance to the station;
- The water leaving the decanter 01 and 02;
- The outlet water of the filter filter 01 and 02;
- Water treated at the tank outlet.

Determination of Aluminum by LCK 301 kit methods:

Chromazurol S forms, with aluminum, in a slightly acidic acetate buffer medium, a green colored lacquer.

Preparation of samples

The pH of the samples should be between 2.5 and 3.5; a higher value causes precipitation in the form of complexes with Aluminum (the measured results will be too low). To avoid this, a few drops of 65% nitric acid (HNO_3) are added to the samples in order to adjust the pH to the permissible limit value.

Sample analysis and quality control

The protocol consists in pipetting 2 ml of the LCK 301 A solution, introducing it into the LCK 301 tube; Add 3 ml of the sample and a spoonful of the LCK 301 B reagent. The vessel is closed and the contents are mixed until the lyophilisate dissolves. After 25 min, measure in the UV VIS spectrometer (DR 6000), which has a wavelength range from 190 to 1100 nm.

The same procedures for quality control are carried out by replacing the sample with the commercially available quality control solution (standard solution LCK 702).

This method allows to analyze the color, UV, undesirable parameters (NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, H_2S, Fe, Mn, Zn, Cu, F^-, $Al_3^{\ +}$). Insert the white tube (ZERO LCK 301) into the appropriate cup holder at the LCK301 tube.

INTERPRETATIONS OF RESULTS

Raw Waters:

The temperature of the raw water is stable, between 13.30°C and 17.45°C, with an average value of 15.39° C. It remains slightly fresh due to the submerged water intake.

The raw water of the dam is slightly alkaline, the pH values are between 7.38 and 7.65 and an average of 7.52, which justifies the use of alumina sulfate as coagulant, figure 4.

The turbidity of the water varies between 0.96 and 2.05 NTU, with an average of 1.32 NTU, these low values being due to the relatively long residence time, which allows a good sedimentation of the suspended particles and the elimination of all the particles, which obey the law of gravitation figure 4.

Aluminum content in raw water is generally low with an average of 0.044 mg/l (trace), less than the required standards for good quality water figure 4. These traces of aluminum, which are found in surface waters, come from the lithology of the watershed of TAKSEBT dominated by impermeable geological formations. There is a wide distribution of the crystallophyllian base surrounded by a sedimentary ensemble composed essentially of clay.

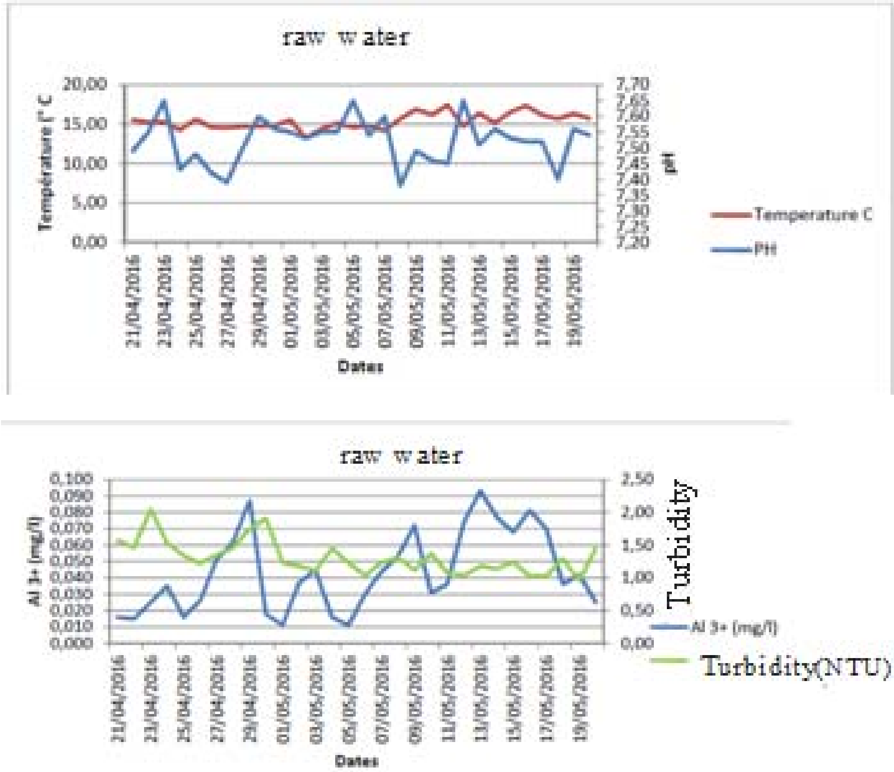

Figure 4. Assessment of some parameters of raw water as a function of time.

Decanting water

Separator 01:

The aluminum tensor in the decanter 01 is large, with a minimum of 0.116 mg/l and a maximum of 0.422 mg/l with an average of 0.227 mg/l. Injection of Aluminum sulfates causes the Aluminum concentration to increase in water, this concentration gradually decreases by formation of flocs (Aluminum - MES) and then sedimentation. The results are shown in figure 5.

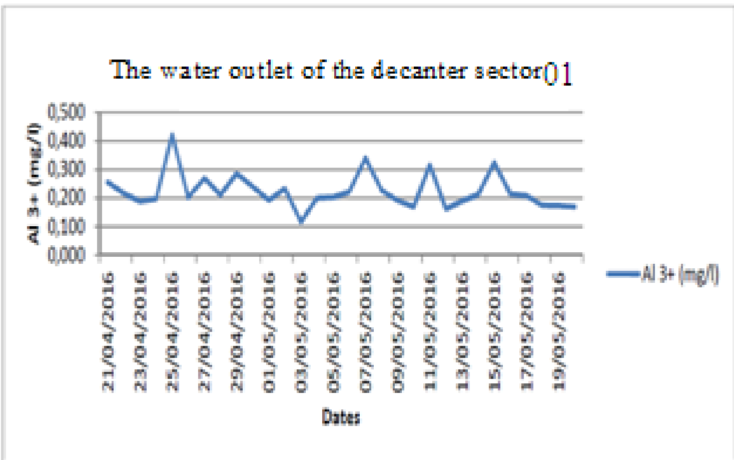

Figure 5. Variation of Al^{3+} concentrations as a function of time in the decanter 1

Decanter die 02:

The aluminum concentrations of the outlet water of the decanter 02 are between 0.069 and 0.502 with an average value of 0.293 mg/l. The results are illustrated in figure 6.

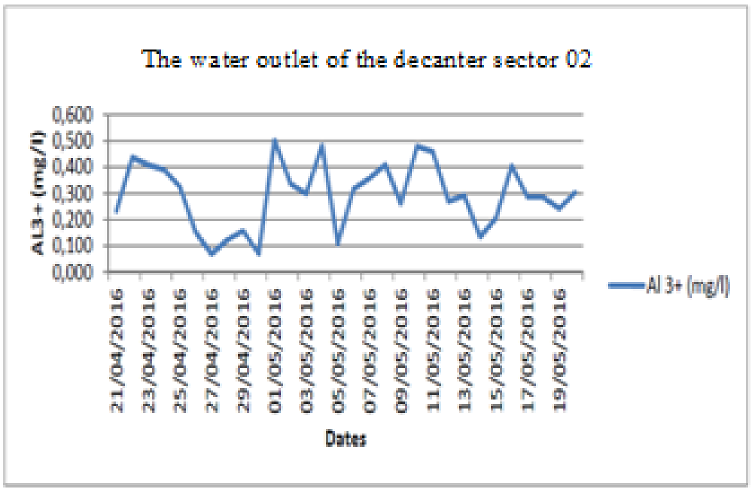

Figure 6. Variation of Al^{3+} concentrations as a function of time in the decanter 2.

Water filters

Filters 01:

Aluminum contents vary with time; the minimum value is 0.024 mg/l and the maximum value is 0.190 mg/l with an average of 0,093 mg/l. The concentration of aluminum decreases further due to retention in the filter, which contains the finest sand layers (very good filtration). The results of the aluminum analyzes are shown in figure 7.

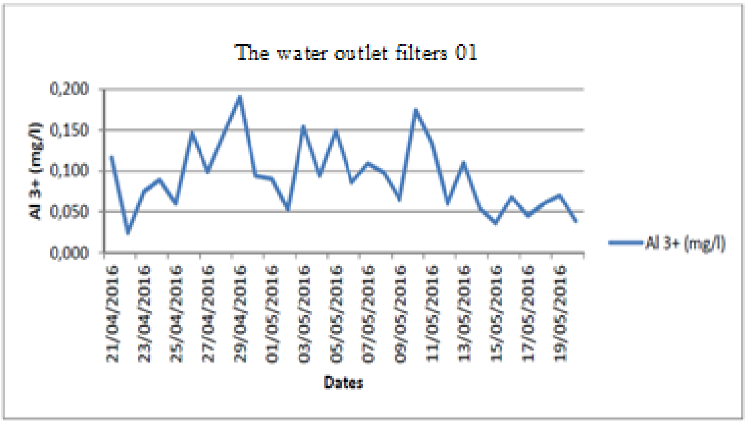

Figure 7. Variation of Al^{3+} time function in filter 1.

Line filter 02: Concentrations range from 0.019 mg/l to 0.110 mg/l with an average of 0.054 mg/l. The results are illustrated in Figure 8.

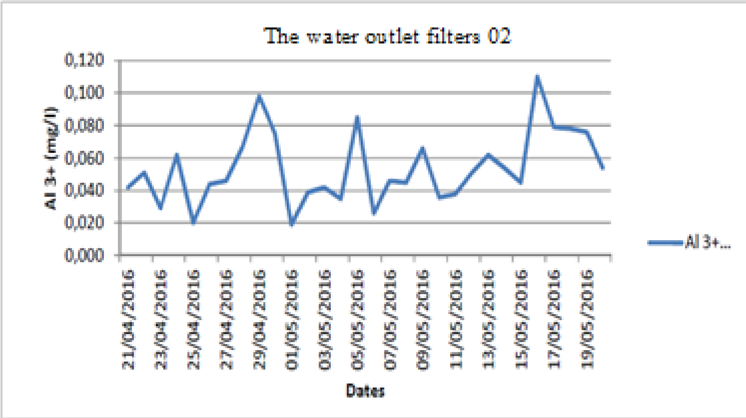

Figure 8. Variation of the Al^{3+} concentrations as a function of time in the filter 2.

Waters Treated

The temperature is between 14.90°C. and 19.60°C, with an average of 16.79°C, the latter being in the range of 12°Cto 25°C which represents the Algerian standard.

The pH is practically stable between 7.33 and 7.58 and meets the standards of potability (6.5-8.5).

Turbidity is low through clarification treatments, which range from 0.10 NTU to 0.16 NTU, with an average of 0.13 NTU; the Algerian standard sets it at 5 NTU.

Aluminum concentrations are unstable between 0.038 mg/l and 0.188 mg/l but remain below the Algerian standard of 0.2 mg/l. The ability of aluminum compounds to dissolve in water depends on its pH; higher pH causes a lower concentration of aluminum in the water figure 9.

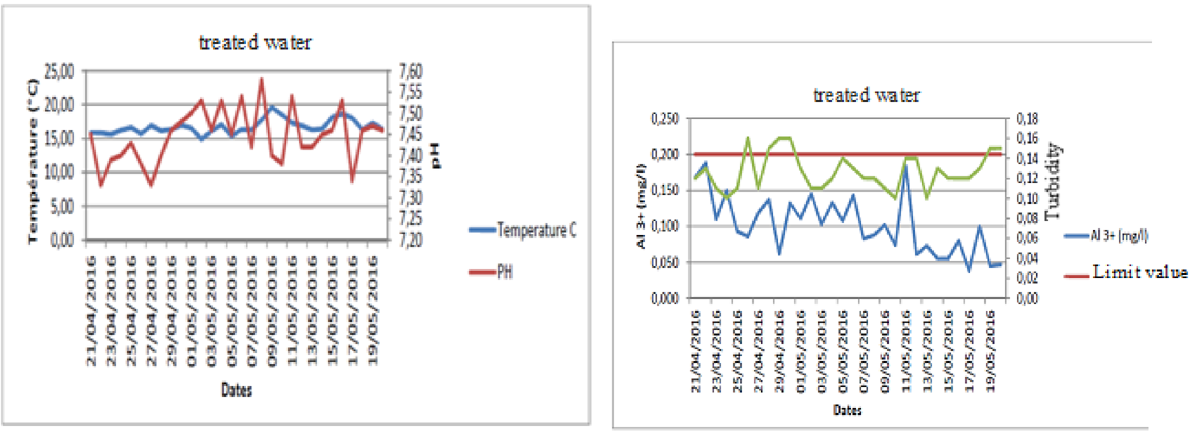

Figure 9. Evaluation of some parameters of treated water as a function of time

Comparison of Aluminum contents the results of the comparison of the Aluminum (Al^{3+}) contents between the raw water and the treated water of the TAKSEBT dam are shown in Figure 10.

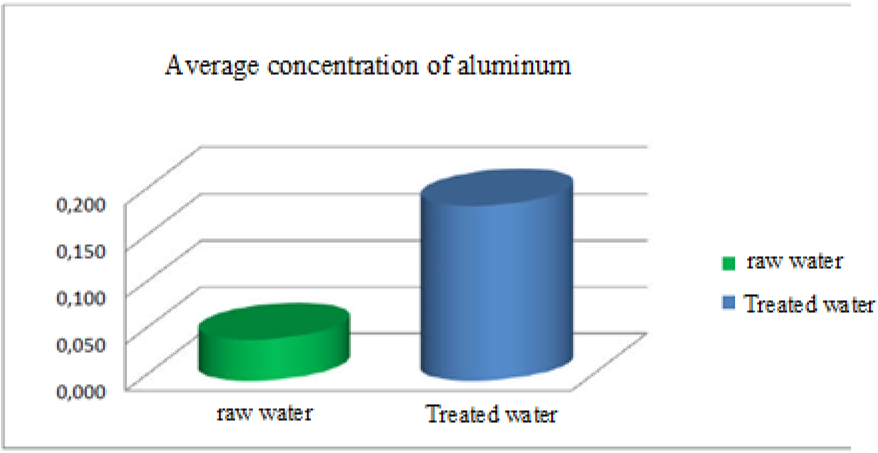

Figure 10. Comparison of Al^{3+} (mg/l) content between raw water and treated water at Taksebt Dam.

According to these results, there is no linear relationship between aluminum concentrations in raw water and treated water. Our results show that the output levels of the station exceed those at the input; this is due to treatment with aluminum sulfate, which produces a residual aluminum concentration, but remains below the Algerian drinking water standard (0.2 mg/l).

CONCLUSION

Water quality for drinking water supply (AEP) is a good response to national and international legal requirements and standards (WHO). For raw water, the results show slightly faint stable temperatures, slightly alkaline pH, low turbidity and low aluminum tensides with an average concentration of 0.044 mg/l. For the treated water, the temperature values are between 12 °C and 25 °C. The pH is between 6.5 and 8.5. With very low turbidity; the aluminum is still present in the water after treatment but has very acceptable concentrations (0.102 mg/l).This is justified by the effectiveness of the treatment inflicted.

These results allow us to draw the following conclusions:

- The raw water of Taksebt is of good quality, it is improved by the treatments carried out at the station;
- For treated water, the results of the parameters studied (Temperature ° C, PH, Turbidity (NTU)) are lower than the standards established by the official journal of the Algerian Republic of drinking water.

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